PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in and relating to Electrodes for Electric Discharge Devices

We, THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, a British Company, having its registered office at Crown House, Aldwych, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates generally to gaseous electric discharge devices or lamps of the type employing ionizable mediums such as gases or vapours, and more particularly to improvements in electric structures used therein.

In many discharge devices manufactured heretofore, the electrodes functioning as cathodes have been activated with materials of low work-function, such as thoria or alkaline earth oxides. These electrodes provide ample electron emission at relatively low electrode temperatures and at low energy consumption for electrode heating. Furthermore, these electrodes also avoid electrode disintegration and envelope blackening from vaporization or sputtering of refractory electrode metal. The sputtering here referred to involves a knocking off of particles from an electrode by positive ions of the operating atmosphere that bombard the electrode under the impulsion of a high voltage drop existing adjacent the electrode while it is functioning as cathode—a cathode drop generally higher than the required ionizing potential of the atmosphere employed. Sputtering is especially apt to occur during the starting of an arc discharge.

Electrodes without activating oxides present difficulties which arise from the high work function of the electrode material and from cathode "hot-spotting", which is a concentration of the discharge and of the heating of the electrode at a point or area so small that it has to be heated much hotter than adjacent areas in order to give emission corresponding to the discharge current. The small hot-spot must yield the required emission thermionically because field emission due to the cathode drop is virtually nil from an unactivated electrode. Thus the hot-spot becomes heated to an excessive temperature at which point the electrode vaporizes rapidly or melts. This produces sputtering during starting, and contributes very little towards electrode heating or useful radiant output, thus causing a relatively poor overall efficiency.

The invention aims at providing an improved electrode structure for such devices which facilitates the starting, at a relatively low voltage, and eliminates, at least partly, hot-spotting and cathode distintegration.

Accordingly the invention relates to an electrical discharge device of the kind including an envelope containing an ionizable medium capable of supporting an arc discharge, and an unactivated hollow electrode providing the electron emission for the arc discharge and comprising a cylindrical portion positioned parallel to the discharge path and a substantially conical portion converging towards the end of the electrode which is connected to a coaxial lead-in wire and resides in that the side wall of the converging portion of the electrode is apertured to provide a gap in the surface of this wall the width of which varies from point to point in the direction of the axis or generatrix of said wall or surface.

Further features and advantages of the invention will appear from the following description taken in connection with the accompanying drawings. Fig. 1 is a diagrammatic view of a lamp according to the invention, and a starting and operating circuit therefore. Fig. 2 is an enlarged perspective view of the electrode structure illustrated in Fig. 1 before it is secured to a lead-in conductor. Fig. 3 is an enlarged perspective view of the electrode structure secured to a lead-in conductor as illustrated in Fig. 1.

Referring to Fig. 1, the discharge device 1 there illustrated is a lamp hav-

ing an elongated vitreous radiation-transmitting discharge envelope 2, in the form of a tube of quartz or glass, provided with self-heating electrode structures 3 and 4 of the unactivated cathode kind in its opposite ends, and permeable to ultra-violet and visible radiation. An auxiliary starting electrode 5 is shown in one end of the envelope 2, closely adjacent the cooperating main electrode 4. Besides an atmosphere of starting gas, such as one of the inert rare gases like argon, krypton, zenon, etc., the envelope 2 contains a vaporizable and ionizable working substace like mercury or other metal, to provide an operating atmosphere preferably at discharge-constricting pressure during operation. The charge or working substance, represented by a mercury droplet 6, may be more than will vaporize under the heat of the lamp, thus assuring operation with an atmosphere of saturated vapour; or it may be less than would afford an unvaporized surplus, so that the lamp will always operate with an unsaturated atmosphere, as is now generally preferred for high-pressure lamps for some applications. In such a device argon at a pressure of 11 mm. of mercury is satisfactory for the starting gas. The envelope proportions illustrated represent a constriction and elongation of the device such that during operation on the rated discharge current a mercury pressure is developed which constricts the arc discharge into a narrow cord along the longitudinal axis of the envelope 2. As shown in Fig. 1, the envelope 2 may be a straight, uniform tube with moulded ends somewhat reduced around the electrode structures 3 and 4 and necks 7 and 8 projecting around the main inlead wires 9 and 10 and the auxiliary inlead wire 11. These necks may embody graded seals, as here shown.

The electrodes 3 and 4, consist merely of bare refractory metal. The auxiliary starting electrode 5 is of an ordinary form, comprising a simple straight piece of refractory metal wire, while the main operating electrode structures 3 and 4 are shaped according to the invention, for the purpose above specified, as will be described later.

Illustrative circuit connections suitable for the starting and operation of the discharge device are shown in Fig. 1 as including a high-leakage reactance transformer 12 of semi-auto type with its primary connected across an a.c. power supply circuit 13 and with its secondary windings 14, 15 connected in series across the main discharge electrodes. Through a high current-limiting resistance 16 and a thermal (bimetallic) switch 17, one of the main electrodes, denoted 4 and the associated auxiliary starting electrode 5 are connected across the transformer secondary windings 14, 15 in parallel with the electrode assemblies 3 and 4. The heating resistor 18 of the thermal switch 17 is shown connected in one side of the secondary circuit to the main electrodes 3 and 4 so as to be heated whenever the arc operates. For a discharge device intended to run on a current of 3 amperes at a voltage of 92.5 volts, the transformer may be so chosen as to produce a voltage of 230 volts across its series connected secondaries 14, 15 on open circuit, and to give a secondary current of about 3.8 amperes on short-circuit.

Under these conditions, energization of the circuit 13 will automatically start the auxiliary discharge across the short gap 4, 5 and then the main discharge across the gap 3, 4. Thereafter the thermal switch 17 will disconnect the auxiliary electrode 5 from the secondary circuit, so that the seal around the leads 9, 11 will not be injured by the voltage subsisting between them when both are in circuit; and this switch 17 will remain open at all times when current is flowing.

Fig. 2 illustrates an enlarged perspective view of one of the electrode structures of Fig. 1, for example electrode structure 3, before the electrode structure is secured to a lead-in conductor of the electric discharge device 1.

Fig. 3 illustrates the electrode structure 3 of Fig. 2 secured to lead-in conductor 10. Electrode structure 3 comprises a hollow metallic cylinder forming the main electrode portion which, for example, may be tantalum with one end thereof slit or provided with integral extension arms 19 which converge for connection to lead-in conductor 10, constitute parts of a cone with inner concave surfaces and form between them an intermediate aperture of gradually varying width.

These bifurcated or extension arms 19 with a gap or aperture between them serve as an arc initiating means by providing a diverging path of travel for a glow discharge in the starting operation of device 1 and also as an intermediary supporting means between the wire 10 and the main electrode portion. Generally speaking at a given voltage between two discharge surfaces a glow discharge is a steady-state self-sustaining discharge. That is, in a glow discharge the secondary electrons liberated per positive ion from the cathode or discharge surface must, in ionization by collision in some essential distance " d ", produce enough new electrons in the gas to maintain the discharge current at its constant value. This indi-

cates that the cathode or discharge surface is an area of vital activity in sustaining a steady glow discharge, or in establishing a satisfactory glow discharge in the arc-initiating mechanism, and also that there is an important distance or length "d" from this area at which point ionization produced by secondary ions occurs. This correct distance "d" depends on many factors, two of them being the starting gas pressure in the electric discharge device and the type of material of the cathode surface. As a glow discharge occurs and continues the gas in the area occupied by the glow discharge rarefies and allows the glow to expand in area.

Heretofore, unactivated hollow cylindrical electrodes have been used in such lamps, but the proper cylinder diameter could not be obtained for the most favourable glow discharge operations because the area occupied by the glow would vary with different discharge devices and in each lamp with time needed for the starting operation.

Therefore, we provide an electrode structure which owing to the gradually varying length of discharge path and area of discharge surface in relation to this length permits a glow discharge to adjust itself for the most favourable operating condition. More particularly, we provide an electrode structure which provides a plurality of optimum spacings wherein a glow discharge may seek an area where secondary electrons liberated by the positive ions from the cathode produce enough new electrons in the gas to maintain the glow discharge current at its constant value. Thus, we provide a hollow cylindrical electrode having a converging apertured portion serving as an arc initiating means by establishing a plurality of optimum spacings wherein a glow discharge may occur under the most favourable operating conditions and continue to remains under these most favourable conditions as the gas within the glow discharge area rarefies.

In addition, by providing the most favourable conditions for starting an arc discharge in an electric discharge device we have inherently reduced the starting voltage necessary. This lower starting voltage in turn greatly reduces if not eliminates sputtering of the electrodes.

It will be understood that the ratio discharge area to length of discharge path upon which the steady self-sustaining glow discharge depends, varies from point to point in the direction of the axis of the converging portion, i.e. along a generatrix of the conical surface of the diverging portion of the electrode the wall of which is apertured to provide a gap therein. Therefore the structure according to the invention will serve to reduce the starting voltage and facilitate striking the arch discharge even if no starting electrode is provided, although in this case the voltage required for striking the arc would be higher than for an arrangement including a starting electrode.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An electrical discharge device of the kind including an envelope containing an ionizable medium capable of supporting an arc discharge, and an unactivated hollow electrode providing the electron emission for the arc discharge and comprising a cylindrical portion positioned parallel to the discharge path and a substantially conical portion converging towards the end of the electrode which is connected to a coaxial lead-in wire wherein the side wall of the converging portion of the electrode is apertured to provide a gap in the surface of this wall the width of which varies from point to point in the direction of the axis or generatrix of said wall or surface.

2. A device as claimed in claim 1 wherein the converging portion comprises two members extending from the end of the cylindrical portion to the coaxial lead-in wire.

3. A device as claimed in claim 1 or 2 wherein the envelope is of elongated shape and two electrodes at its opposite ends are both apertured at their converging portions.

4. A device as claimed in any of the preceding claims including a starting electrode of elongated shape positioned near the converging portion of the electrode and parallel to the axis thereof.

5. A device as claimed in claims 3 and 4 wherein the starting electrode is connected to the electrode at the far end of the envelope via a resistance and thermal switch.

6. A device as claimed in any of the preceding claims wherein the electrode structure is of tantalum.

7. An electric discharge device substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Dated this 26th day of November, 1948.

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FIG. 1.

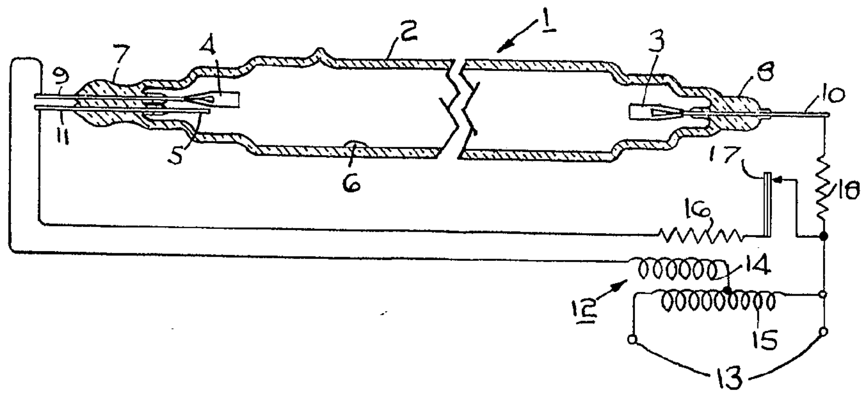

FIG. 2.

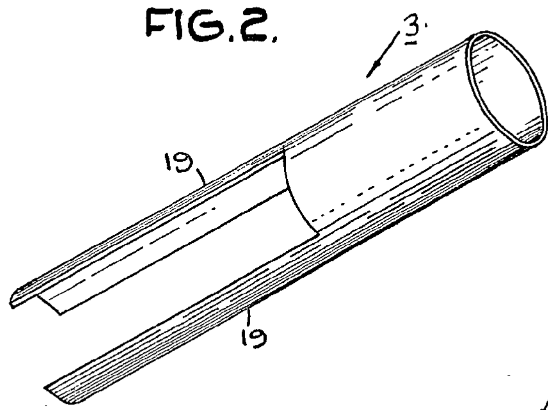

FIG. 3.